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Forecasting of Milk Production in Tamil Nadu using the Arima Model

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Abstract

The study is to predict milk construction in Tamil Nadu using a stochastic model. This study framed a model on the basis of the data obtain from NDDB information. This study cover the era from 1979–80 to 2018–19. The obtained time series data were systematically processed under all conditions of Box Jenkins methodology, such as identification, estimation and diagnostic checking. The study used Statistical Package for the Social Sciences package software for forecasting the model. The study establish that the ARIMA model (1, 1, 0) was an suitable model for opinion. This model had a low BIC value, a good R square value, a significant p value, and satisfied other model fit parameters such as RMSE and MAPE. Based on the model fit statistics, the study estimated that the milk production of Tamil Nadu would increase from 8711.74 thousand metric tonnes in 2019–20 to 9886.26 thousand metric tonnes in 2025–26.

Keywords: *Stochastic Model, Time Series Data, Box Jenkin's Model, Bayesian Information Criterion (BIC).*

1. Introduction

Tamil Nadu is a milk - produce state and is ranked 10th in the list of the top 10 milk - produce states in India. As per the 20th Livestock Census (2019), the total number of livestock in Tamil Nadu was 24.45 million. The total number of cattle has increased from 8.81 million in 2012 to 9.47 million in 2019. Likewise, the number of exotic or crossbred cows has increased from 6.35 million in 2012 to 7.68 million in 2019. At the same time, the number of indigenous cows has declined from 2.46 million in 2012 to 1.79 million in 2019. In 2019, the number of crossbred and indigenous milch cows was 3.02 million and 0.51 million, respectively. The number of milch buffaloes has decreased from 2.6 lakh in 2012 to 1.9 lakh in 2019.

Tamil Nadu ranks seventh among states with the largest number of dairy cooperative societies in India and third among states with the highest number of milk producer members. According to the National Dairy Development Board (NDDB) Annual Report 2018-19, the state of Tamil Nadu has 10,677 dairy cooperative societies, which is 5.60 percent of the total dairy cooperative societies in the country. whereas the state has 18.7 lakh milk producer members, which is 11.05 percent of the total milk producer members of the country.

Milk production in Tamil Nadu has increased to 8.36 million tonnes in 2018-19 from 3.37 million tonnes in 1990–91. Shri Dilip Rath (2019), Chairman of the NDDB, said that the net daily income of Tamil Nadu milch farmers has increased by Rs. 32.80 per animal per day. However, the contribution of Tamil Nadu to the country's total milk production continues to be low. For example, the payment of Tamil Nadu to the total milk construction of the country in 2006–07 was 6.13 percent. It was 5.61 percent in 2011–12. It further declined to 4.45% in 2018–19. In fact, the payment of Tamil Nadu to total milk manufacture in India has been incessantly below 5 % since 2013–14. Besides, Tamil Nadu secured eight positions in the country's milk production share in 2006–07, which has fallen to the tenth position in 2018–19. This reveals that Tamil Nadu is lagging behind the total country's milk production.

2. Review of Literature

Many study have utilised time series examination to approximation India, Tamil Nadu, and global milk production. This time series analysis has been utilised in various forecasting methodologies. Box-Jenkin's Methodology of the ARIMA and SARIMA models, the Ordinary Least Square (OLS) Method, the Weighted Regression Function, and the Wood Function are a few examples. The methodology of Box Jenkin's ARIMA model has been utilised in numerous research articles to forecast milk production. In general, Box-Jenkin's methodology for the ARIMA model consists of three stages: model identification, model estimation, and diagnostic testing. The time series data were analysed using the IBM SPSS package, GRETL software, MINITAB software, SAS software, MS-Office Excel, and "R" utilities. The following is the literature reviewed in detail in this paper:

Deluykeret al.(1990) study estimated daily milk yield in Holstein cows using time series analysis. The study establish that the ARIMA (0, 1, 1) model, also recognized as the exponential smooth model, was fit to the everyday yield from heifers and diverse cows not treated for illness and without absent milk weights.

SanaoKatkasame et al. (1996) studied trend analysis on milk production traits in the dairy farming promotion organisation of Thailand. The study establish that the phenotypic trend on milk give way, milk fat, and fat gain obtained from a biased weakening method was 37.22 kg, 1.32 kg, and -0.0104%, in that order. The hereditary trend on milk yield, milk fat, and fat proportion obtain from a biased weakening method was 45.05 kg, 0.448 kg, and -0.0544%, in that order.

Heman D. Lohano and Fateh M. Soomro (2006) predict milk construction in Pakistan by using the Ordinary Least Squares (OLS) scheme. The study found a positive trend in milk production during the years from 1971–72 to 2004–05. The forecasted milk production of Pakistan increased from 30.70 million tonnes in 2005-06 to 44.33 for the year 2014-15.

Farhan Ahmed et al. (2011) estimated milk production in Pakistan using the ARIMA model. The aim of the study was to estimate milk production in Pakistan for the period 2010–11 to 2014–15. The study recognized the ARIMA (1, 1, 1) model as an suitable model for opinion and forecasted the rising trend of milk manufacture in Pakistan. The study estimated that the milk production of Pakistan would increase to 47494.2 thousand tonnes in 2015-16 from 39650.1 thousand tonnes in 1990–91.

Jai Sankar and Prabhakaran (2012) predict milk production in Tamil Nadu by the ARIMA model. The study establish that the ARIMA (1, 1, 0) model was improved suited for opinion. The study estimated that the milk production of Tamil Nadu would rise from 5.96 million tonnes in 2008 to 7.15 million tonnes in 2015.

Bjorn Gunnar Hansen (2014) studied dissimilar methods to predict milk release to dairy: A contrast for forecasting. The model values of AIC, BIC, Variance and Likelihood were 2016.31, 2051.06, 4932115 and -995.16 respectively.

Lyhen Sanchez *et al.* (2014) made study on use of ARIMA model for predict milk construction case learn in UBPC "Maniabo, Lastunas. The study approximate with $p \leq 1$ and $q \leq 3$ of dissimilar ARIMA model test. ARIMA (1,0,3) x(0,1,0)12 was think as best model healthy.

Ranjit Kumar Paul *et al.* (2014) studied the prospects of livestock and dairy production in India under time series framework. The study was fitted ARIMA (1,1,0) model based on the model fit statistics such as Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Relative Mean Absolute Error (RMAE) and Relative Mean Absolute Prediction Error (RMAPE). The study forecasted that milk production in India increased to 144.23 million tonnes in 2015 from 112.2 million tonnes in 2008.

SagarSurendraDeshmukh and Paramasivam(2016) studied jointly forecasting of milk production in India with ARIMA and VAR time series model. The study found that the two different models for the same time series data such as ARIMA (1, 1, 0) model from SPSS Package and ARIMA (1, 0, 0) from GRETL software. The respective SPSS Package and GRETL software results of forecasted milk production of India for the year 2017 were 160 million tonnes and 163 million tonnes.

Jamal Fattah et al. (2018) study estimated the demand in the food industry by using the Box-Jenkins methodology of the ARIMA model. The study found that the ARIMA model was statistically fit in the (1,0,1) model with certain criteria minimized, such as AIC, SBE, variance, and maximum likelihood.

Safa Abdel Gadier Hassan et al. (2018) deliberate milk production forecasting in Khartoum state, Sudan. The study found that the ARIMA (1, 0, 0) model fit.

This model has a low BIC value, a good R square value, and satisfies other model fit parameters such as RMSE and MAPE. Based on the model fitted, forecasted milk production in India for the years 2019–20 and 2025–25 is 198.8 Million tonnes and 285.8 million tonnes respectively.

3. Method and Materials

The study is based on secondary data. The data were obtained from the NDDB reports from 1979-80 to 2018-19, published by the Government of India. Jamal Fattah et al 2018 stated that each time we need to feed the historical data with the new data to enrich model in order to improve the new model and forecasting. In this perspective, this study aimed to enriches the model based on the 4 decades (40 years) data of milk production in Tamil Nadu for the period from 1979-80 to 2018-19. The data is process by using arithmetical wrap up for Social Science (SPSS) software.

Box-Jenkin's methodology of the Autoregressive Integrated Moving Average (ARIMA) model is used in this study. This model is approved out in three stage, viz. identification, estimation, and diagnostic checking. In ARIMA (p, d, q) series, p denotes the autoregressive (AR), q denotes the moving average (MA), and d denotes the number of times the series has to be differenced before it becomes stationary (I). d is a nonnegative integer. When d is zero, the ARIMA (p, d.q.) model reduces to the ARIMA (p,q) model.
Auto Regressive Process of order (p) is

$$Y_{t=\mu+\phi_1 Y_{t-1}+\phi_2 Y_{t-2}+\ldots\ldots+\phi_p Y_{t-p}}+\varepsilon_t$$

Moving Average Process of order (q) is,

$$Y_{t=\mu-\theta_1\epsilon_{t-1}-\theta_2\epsilon_{t-1}-\cdots\ldots-\theta_q\epsilon_{t-q}}+\varepsilon_t$$

And the universal form of ARIMA representation of order (p,d,q) is
Where, Y_t is milk production, ϵ_t are independently and normally distributed with zero mean and constant variance for t=1, 2……. n; and ϕ_p and Θ_q are also estimated.
BIC principles for ARIMA model are compute by

$$BIC_{(p,q)} = Lnv^*(p+q) + (p+q)\ [\ln(n)/n]$$

$$MAPE = \frac{1}{n}\sum_{t-1}^{n} \left|\frac{Y_t - F_t}{Y_t} x\ 100\right.$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{t-1}^{n}(Y_t - F_t)^2}$$

Where n denotes the number of observations used for estimation of parameters and σ^2 denotes the Mean square error.
where Y-t is the actual original milk yield in different years, F-t is the forecasted milk yield in the corresponding years, and n is the number of years used as the forecasting period. The ARIMA model developed by Box-Jenkins is used to predict future milk production in Tamil Nadu.

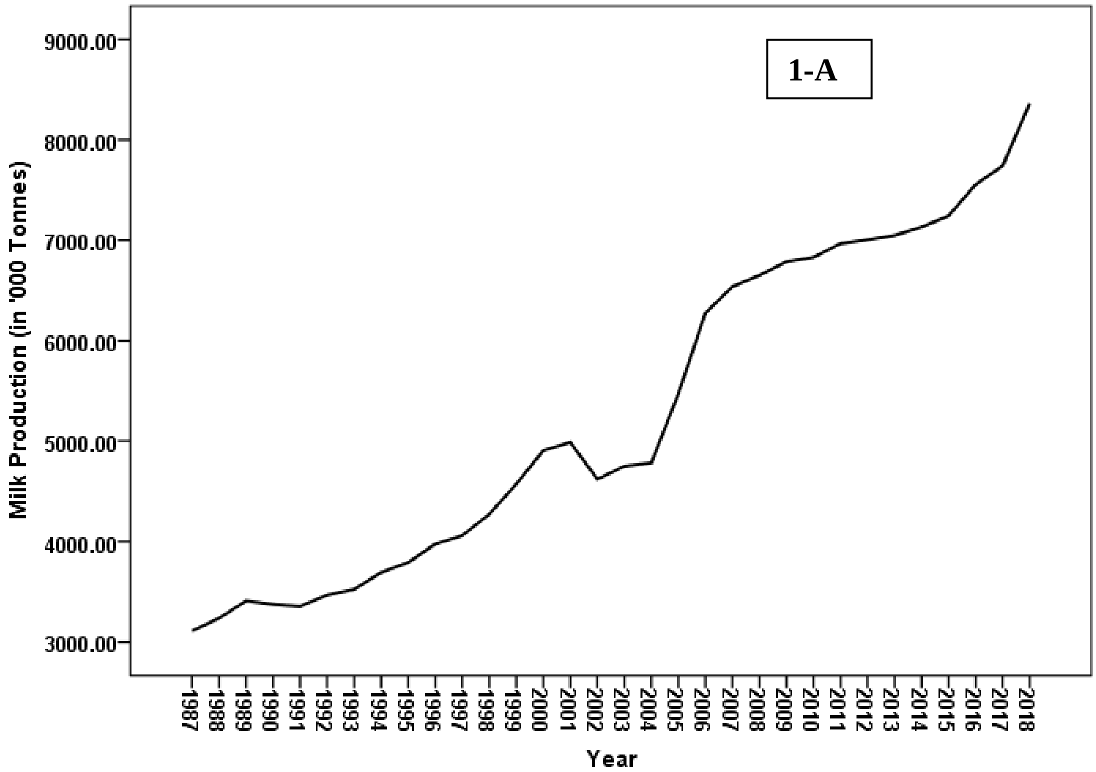
4. Result and Discussion:

a) Model Identification

The ARIMA model is used to predict milk construction. This might be possible at what time the data is a motionless series. Suppose the data is non-stationary; then it should be transformed into a stationary state. The differencing of first command and second command is Yt-Y t-1 and Yt-Y t-2, in that order. Usually, the alteration is frequent until the data attain a motionless state. In this study, Yt is found to be non-stationary, and first-order differencing is done with the intention of attaining stationary. Figure 1A shows the real sequence of milk production and reveals the non-stationary natural world of the data. Figure 1B shows the stationary data. The previous non-stationary data was converted by first-order differencing.

Deluyker, H.A., et al. (1990) stated that the autocorrelation reflects the degree of correlation within a series of repeated measurements between observations at a fixed interval. The partial autocorrelation also measures the degree of linear association between observations at a fixed interval. The autocorrelations and biased autocorrelations were first used to decide whether the mean of the frequent capacity remain stable during the surveillance period (the motionless state).

Figure 1: Milk production in Tamil Nadu actual line and 1st order difference line



The ACF and PACF of milk production in India are presented in Table 1. The values of ACF and PACF lie between -0.5 and +0.5. It means that milk production in Tamil Nadu is stationary. When taking the first order difference of the original series, Box LJung statistics show only a few lag values are significant in the autocorrelation function, as shown in figure 2.

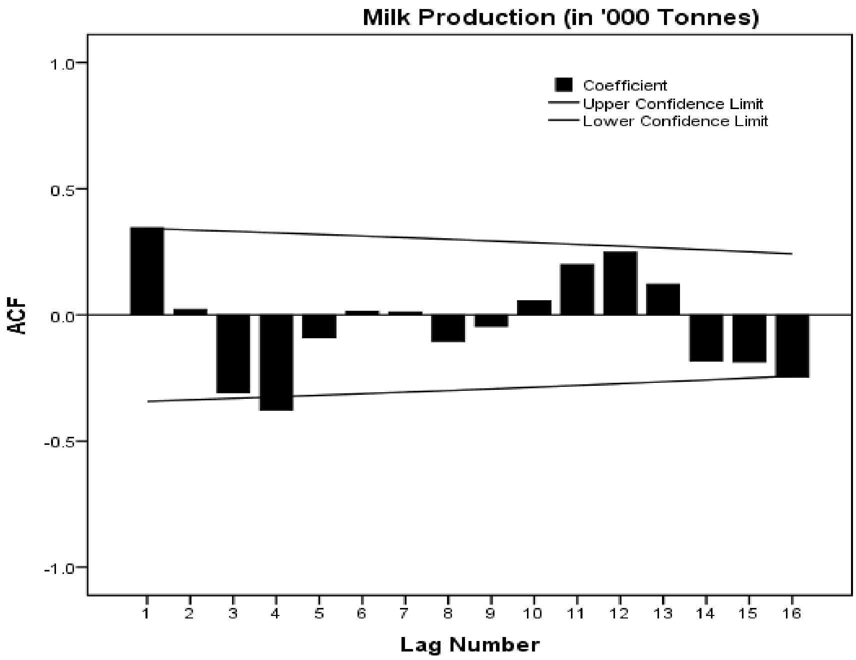
Table 1: ACF and PACF of Milk Production in Tamil Nadu (in '000 Tonnes)

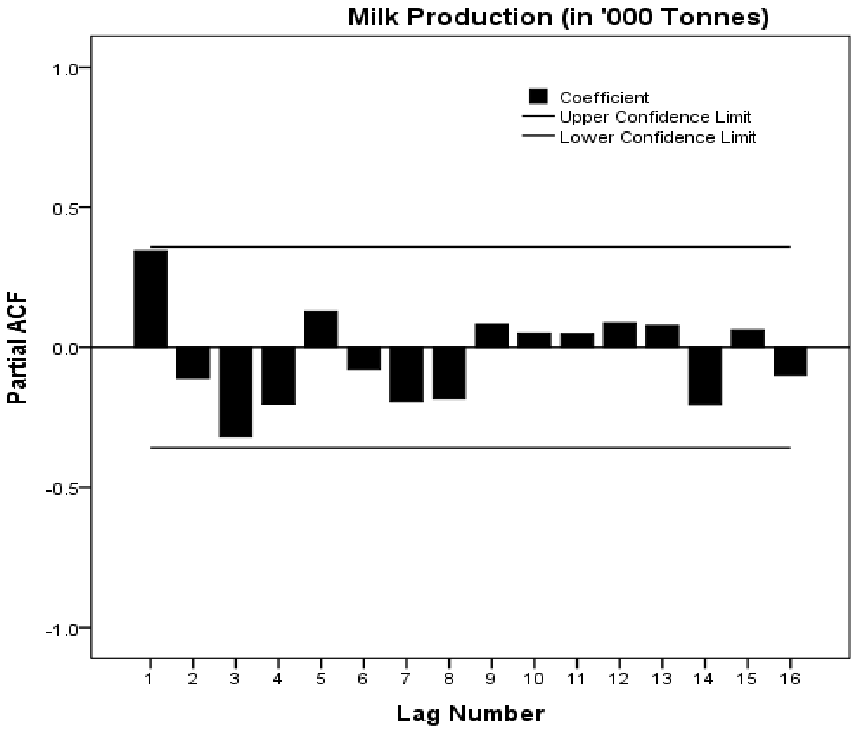
Lag	Auto -correlation	Std. Error[a]	Box-Ljung Statistic			Partial Autocorrelation	Std. Error[a]
			Value	df	Sig.[b]		
1	0.345	0.171	4.061	1	0.044	0.345	0.180
2	0.021	0.168	4.076	2	0.130	-0.111	0.180
3	-0.308	0.165	7.552	3	0.056	-0.320	0.180
4	-0.376	0.162	12.917	4	0.012	-0.203	0.180
5	-0.090	0.159	13.237	5	0.021	0.128	0.180
6	0.014	0.156	13.245	6	0.039	-0.078	0.180
7	0.010	0.153	13.249	7	0.066	-0.194	0.180
8	-0.104	0.150	13.729	8	0.089	-0.183	0.180
9	-0.046	0.147	13.826	9	0.129	0.083	0.180
10	0.056	0.143	13.981	10	0.174	0.049	0.180
11	0.199	0.140	16.015	11	0.141	0.047	0.180
12	0.248	0.136	19.332	12	0.081	0.087	0.180
13	0.121	0.133	20.165	13	0.091	0.079	0.180
14	-0.183	0.129	22.173	14	0.075	-0.206	0.180
15	-0.187	0.125	24.398	15	0.059	0.061	0.180
16	-0.245	0.121	28.505	16	0.027	-0.100	0.180

Source: Computed by Author

a. The fundamental process supposed is self-government (white noise).
b. Based on the asymptotic chi-square approximation.

Figure.2. ACF and biased ACF of milk construction presentation of Tamil Nadu





b) Estimation of the ARIMA Coefficient

Jaisankar and Vijayalakshmi (2017) have selected the best ARIMA model based on the normalised BIC value, a good R squared value, and model fit statistics such as RMSE and MAPE.

Table 2: Coefficients of different ARIMA models for milk production in Tamil Nadu during the period from 1987-88 to 2018-19

Characteristics \ Model	Model Parameter (p,d,q)	ARIMA (0,1,0)	ARIMA (0,1,1)	ARIMA (0,1,2)	ARIMA (1,0,3)	ARIMA (1,4,1)	ARIMA (1,3,2)	ARIMA (2,1,0)	ARIMA (2,1,1)	ARIMA (2,1,2)
AR(1)	α1				**0.350**	0.203	0.676	0.412	1.186	0.386
	SEB				**0.182**	0.528	0.345	0.196	0.186	0.223
	T Value				**1.918**	0.386	1.963	2.099	6.364	1.733
	ρ value				**0.065**	0.703	0.060	0.045	0.000	0.095
MA (1)	ϴ1		-0.373	-0.398		-0.179	0.571		0.992	-0.024
	SEB		0.195	0.189		0.536	67.360		2.083	0.174
	T Value		-1.916	-2.105		-0.335	0.008		0.476	-0.140
	ρ value		0.065	0.044		0.740	0.993		0.638	0.890
AR(2)	α1							-0.166	-0.531	-0.631
	SEB							0.196	0.175	0.217
	T Value							-0.847	-3.035	-2.903
	ρ value							0.404	0.005	0.007

MA (2)	Θ1			-0.364			0.429			-0.987
	SEB			0.191			28.761			2.249
	T Value			-1.911			0.015			-0.439
	ρ value			0.066			0.988			0.664
Constant	Estimate	169.44	174.23	179.07	**1.190**	1.185	1.179	1.173	1.200	1.209
	SEB	39.317	50.735	63.741	**0.378**	0.370	0.103	0.331	0.070	0.351
	T Value	4.310	3.434	2.809	**3.150**	3.205	11.483	3.542	17.112	3.443
	ρ value	0.000	0.002	0.009	**0.004**	0.003	0.000	0.001	0.000	0.002
Model Fit Statistics	Stationary R-squared	0.000	0.134	0.178	**0.120**	0.129	0.223	0.145	0.317	0.327
	R-squared	0.983	0.982	0.985	**0.985**	0.985	0.986	0.985	0.989	0.988
	RMSE	218.90	207.19	205.38	**205.069**	207.38	198.16	205.41	184.53	187.13
	MAPE	2.720	2.675	2.660	**2.659**	2.661	2.530	2.634	2.463	2.472
	MaxAPE	11.578	10.739	10.895	**10.953**	10.657	10.407	10.476	10.247	10.543
	MAE	142.87	138.16	139.64	**140.419**	140.06	131.47	138.03	127.56	128.22
	MaxAE	632.95	587.83	503.60	**568.987**	577.87	481.03	573.42	473.64	487.32
	Normalized BIC	10.888	10.889	10.982	**10.868**	11.002	11.021	10.982	10.879	11.018

Source: Computed by Author, ARIMA: Autoregressive Integrated Moving Average; SEB – Standard Error of B (B: regression Coefficient); BIC – Bayesians Information Criteria, MAPE- Mean Absolute Prediction Error; RMSE- Root Mean Square error;

Sagar SurendraDeshmukh and Paramasivam (2016) have fitted an accurate model based on the criteria of minimum MAPE and BIC values. Lyhen Sanchez et al. (2014) fitted the best ARIMA model based on the statistical criteria of classical errors such as RMSE, MAE, MAPE, ME and MPE

The normalised BIC values of the respective ARIMA models were 10.888, 10.889, 10.982, 10.868, 11.002, 11.021, 10.982, 10.879 and 11.018. It reveals that the ARIMA model (1.1.0) has the lowest normalised BIC value, i.e., 10.868, and the greatest R2 value, i.e., 0.984. Furthermore, the p value is important at the one percent level. While it has good model fit statistics such as RMSE (205.069) and MAPE (2.659). so, ARIMA (1.1.0) is cautious the best model healthy. Similar results were found in the studies conducted by Jaisankar and Prabakaran (2012) as well as Paari and Sathish (2017).

c) Diagnostic Checking

Residuals of ACF and PACF were used for confirmation of the model, and Box L-Jung data were used to test the meaning level (JaiSankar and Prabakaran (2012), Ranjit Kumar Paul et al. (2014)). For the diagnostic checking, residuals of ACF and PACF up to 16 lags were assessed, and Box L-Junk statistics were used to test the significance level. The consequence prove that none of the ACF and PACF values considerably differ from zero at any sensible level, as exposed in Table 3 and Figure 3. So, the next ARIMA model for milk construction in Tamil Nadu is a suitable replica for forecasting.

$$\boldsymbol{Y_t = 1.190 + 0.350Y_{t-1} + \epsilon_t}$$

Figure.3: Residuals of ACF-PACF of milk construction in Tamil Nadu

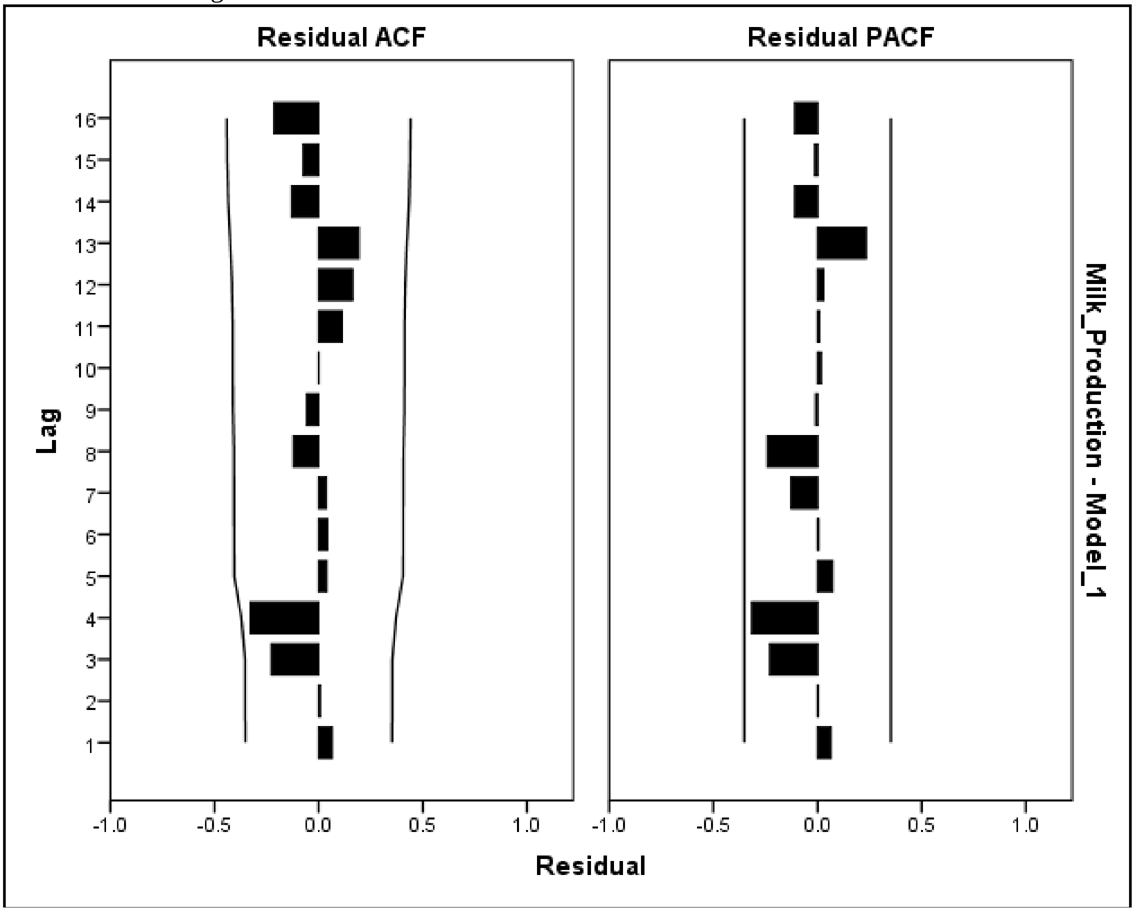


Table 3: Residual of ACF and PACF of milk production in Tamil Nadu

Lag	Residual ACF		Residual PACF	
	ACF	SE	PACF	SE
1	0.064	0.180	0.064	0.180
2	0.007	0.180	0.003	0.180
3	-0.227	0.180	-0.229	0.180
4	-0.327	0.189	-0.315	0.180
5	0.038	0.207	0.074	0.180
6	0.043	0.207	0.006	0.180
7	0.036	0.207	-0.126	0.180
8	-0.122	0.207	-0.241	0.180
9	-0.057	0.210	-0.010	0.180
10	0.002	0.210	0.017	0.180
11	0.112	0.210	0.010	0.180
12	0.163	0.212	0.028	0.180
13	0.193	0.216	0.232	0.180
14	-0.130	0.222	-0.108	0.180
15	-0.075	0.224	-0.013	0.180
16	-0.214	0.225	-0.108	0.180

Source: Computed by Author

d) Forecasting:

SafaAbdelgadier Hassan (2018) referred to the fact that the results of the model help in forecasting the accurate performance of dairy production. A schoolwork by Rajit Kumar Paul et al. (2014) optional the ARIMA model to give direct hold up for the possible uses of precise forecasting in decision-making and stock organization in India. Jaisankar and Prabakaran (2012) fixed that the ARIMA model can be careful for prospect rule creation and formulate strategy for augment and filling milk construction in the state. Moreover, it may provide managers of the manufacturing industry with reliable guidance for decision-making.

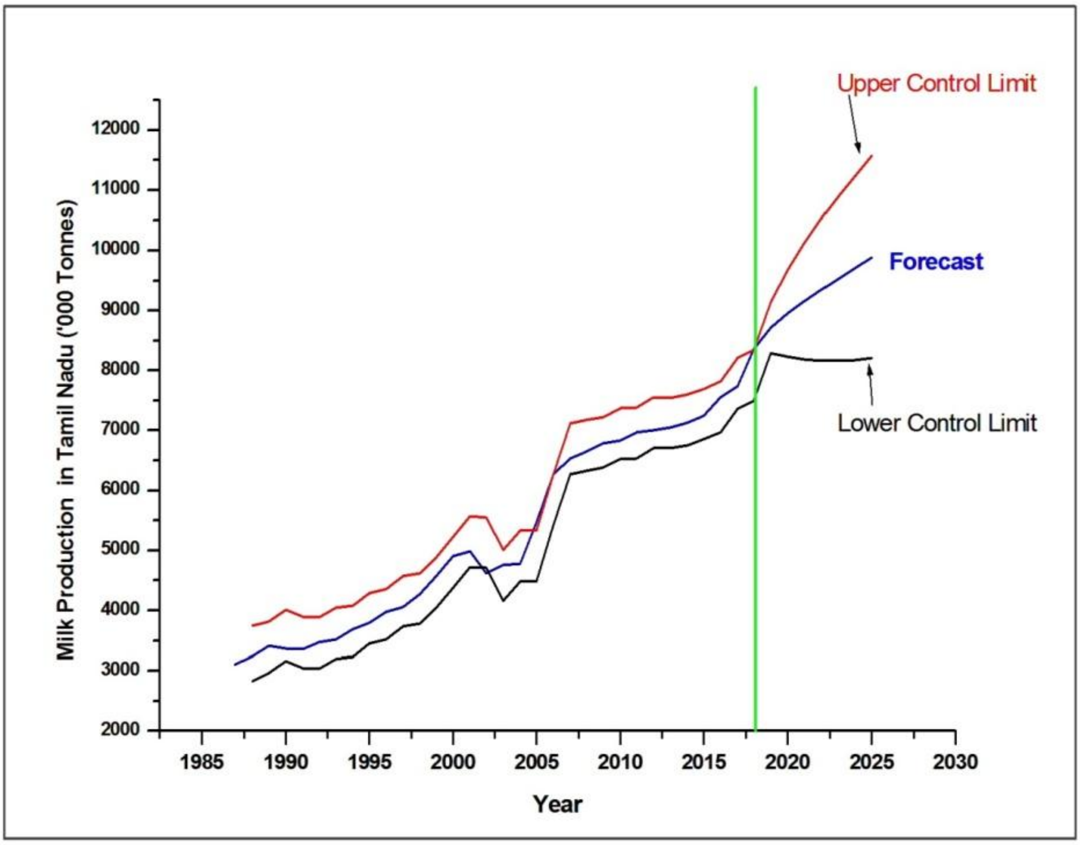
ARIMA model fit (1, 1, 0) is used to forecast the performance of milk production in Tamil Nadu for the period of seven years from 2019–20 to 2025–26. The estimated milk production of Tamil Nadu for the corresponding period is 8711.74, 8956.26, 9159.90, 9347.58, 9529.07, 9708.13, and 9886.26, as shown in table 4 and figure 4. The milk production model fit line for the period of 1979–80 to 2018–19 and the estimated milk production line from 2019–20 to 2025–26, upper control limit and lower control limit for the period of 1979–80 to 2025–26 It reveals high fluctuations in milk production in Tamil Nadu between the years 2000 and 2005, and the remaining line exposes an increasing gradient in the milk building of Tamil Nadu.

Table 4: Forecast of milk production in Tamil Nadu '000 Tonnes from 2019-20 to 2025-26

Year	2018-19	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Forecast	8711.74	8956.29	9159.90	9347.58	9529.07	9708.13	9886.26
UCL	9134.18	9679.38	10132.77	10532.11	10897.62	11240.43	11567.03
LCL	8289.29	8233.20	8187.04	8163.06	8160.51	8175.83	8205.49

Source: Computed by Author, LCL– Lower Control Limit; UCL –Upper Control Limit

Fig.4: Forecast of milk production in Tamil Nadu from 2019-20 to 2025-26



5. Conclusion

The forecasting technique helps frame future policy and formulate strategies for augmenting sustainable milk production. The ARIMA model urbanized by Box- Jenkins method was used to predict milk production in Tamil Nadu. This study covers the period from 1979–80 to 2018-19. The obtained time series data are systematically processed under all conditions of Box Jenkins methodology, such as identification, estimation of the ARIMA coefficient, diagnostic checking, and forecasting, using SPSS package software. The study identified that the ARIMA model (1, 1, 0) is an appropriate model for estimation. This model has a low BIC value, a good R square value, a significant p value, and satisfies other model fit parameters such as RMSE and MAPE. Based on the model fit statistics, the study estimated that the milk production of Tamil Nadu would increase to 9886.26 thousand tonnes in 2025–26 from 8711.74 thousand tonnes in 2019-20.

The study reveals that milk production will increase considerably in the coming years in Tamil Nadu. Hence, the government should pay great attention to establishing several milk chilling plants near the villages to maintain the quality and quantity of milk production in the future. Besides, the cost of milk production varies every year due to the annual hike in inputs, especially concentrates such as oil cakes, cereal grains, rice bran, wheat bran and gram husk. Therefore, it is highly essential to raise the milk price annually to safeguard the farmers' interest in milk production.

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